

The Cultivation of Truffles in Italy

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Abstract: In order to provide a general picture of Italian truffle-growing . We done two parts work . (1) The evolution which the cultivation of truffles has undergone in Italy right from its beginning; (2) The current situation including the unitary productions recorded in the cultivated truffle-grounds .

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The Evolution of truffle-growing in Italy

We can pinpoint four different periods in Italian truffle-growing:

First period (up to 1800): This period corresponds to the empirical cultivation, which is carried out by sowing the seeds of the fruiting bodies: the period ends round about 1800 when the dependence of truffles on superior plants is detected (Mannozi-Torini, 1956; Ceruti, 1990) . In 1564, Alfonso Ciccarello, a doctor from Bevagna (Perugia, Italy), describes truffle cultivation in the following way: “ I would take the truffles along with the freshly dug earth, I would cut them up into small pieces and I would mix them with the earth, then I would bury everything in a suitable place during the autumn and I would sprinkle the place again and again with a decoction of truffles, so that the earth in that place would gather the generative strength in the best possible way, and in this manner I could be sure that the truffles would sprout ” (Ciccarello, 1564) . If we disregard the magical piece of advice about the sprinkling with a decoction of truffles, the distribution of spores at the time of transplanting in the field of mycorrhized plants and in the not very productive truffle-grounds is a practice which is recommended even today, as we shall see later on .

Second period (1810-1930): The cultivation of truffles was attempted by sowing the so-called “ truffle acorns ”, that is to say acorns produced from oaks-trees which produce truffles . Unlike what was taking place

in France, the direct sowing of the truffle acorns in Italy did not have an analogous evolution for various reasons: in the truffle areas agriculture was very poor and the farmers were forced to cultivate all available land in order to be able to survive, and also because the few rare attempts had not been successful . This period ends when Francolini (1919, 1931) introduces the truffle plant . The author, in fact, sows the truffle acorns in a nursery and afterwards transfers them to the field (Mannozi-Torini, 1970) .

In the first two periods, attention was paid exclusively to the black truffle (*Tuber melanosporum* Vittad .), a species widespread in France, Italy and Spain and characterized by the formation of “ pianelli ” (harvesting grounds where the grass does not grow) and thereby easier to detect and harvest (Montacchini and Caramello Lomagno, 1977; Montacchini *et al.*, 1972, 1977) .

Third period (1931-1985): Attempts at mycorrhization are carried out in order to produce truffle plants on a large scale (Fassi and Fontana, 1967, 1969; Fontana, 1967; Palenzona, 1969; Palenzona *et al.*, 1972; Palenzona and Fontana, 1978; Bencivenga, 1982) . The first nurseries producing mycorrhized plants spring up (Fig.2) and modern truffle-growing is launched . The nurseries (Fig.1) began to produce mycorrhized plants (Fig.2) with several species of symbiont plants and the majority of Italian edible truffles: about thirty different combinations of plant-truffle

The efforts of the various authors took shape in the current production of plants which are well mycorrhized, robust and free from pollutant fungi .

In the same period the mycorrhizae produced from the different species of truffle are studied with the aim of controlling and certifying the mycorrhized plants . From the morphological point of view, the mycorrhizae produced from the different species of truffle are meticulously described by various authors (Granetti, 1994, 1995, Granetti *et al.*, 1995a, b; Bencivenga *et al.*, 1995a; Zambonelli *et al.*, 1993) . To fill up the periods during which the mycorrhizae are lacking in structures of a diagnostic interest (spinules, peritrophic mycelium) and therefore of difficult recognition on a morphological basis, immunological analyses (Zambonelli *et al.*, 1993, Zambonelli and Poggi Pollini, 1993), and more recently biomolecular analyses (Mello *et al.*, 1998, 2001; Paolocci *et al.*, 1995, 1999, 2001) have been resorted too .

The research done on the mycorrhizae, and the experience of various experts in the field, have led to the drafting of an objective method for morphological analysis and for the certification of mycorrhized plants (Bencivenga *et al.*, 1987) which are placed on the market in Italy .

This research, together with the possibility of controlling and certifying the truffle plants, has encouraged the nurserymen to certify their plants and the truffle-farmers to request the mycorrhization certificate . To conclude, well-mycorrhized truffle plants with a certificate are almost exclusively bedded out in Italy these days . Together with the improvement in the mycorrhized plants, the researchers have felt the need to study the ecological requirements of the different species of truffle with the practical aim of identifying the environments in which to set up the truffle-grounds and creating potential techniques for cultivating them . Many authors have tried to study the ground where truffles grow spontaneously (Bragato *et al.*, 2001; Lulli and Primavera 1995, 2001; Raglione *et al.*, 2001) while others have deliberated the vegetational, pedological and climatic aspects of their composition (Bencivenga, 1994; Bencivenga and Granetti, 1990; Bencivenga *et al.*, 1990, 1992, 1995b, 1996) .

The results of this research permit a good approximate identification of the areas suitable for the cultivation of one or another species of truffle . The sector, however, needs further investigations, especially in the case of the microflora and the microfauna in the ground which have not yet been studied enough .

The last field of research, which unfortunately sees the involvement of only a scanty number of researchers, consists of the study of the cultivation techniques of the truffle plants after they have been placed for bedding out . It is a difficult research as it is not always possible to have at one's disposal uniformly productive truffle-grounds in which to set up an experimental trial, the theories of which could turn out to be harmful to that very same truffle ground . Moreover, working outdoors, it becomes difficult to interpret the results because many external factors intervene, and not all of them are controllable . Even with these limitations it is necessary to proceed with the research as it has been noted that artificial truffle-grounds not subjected to cultivating interventions yield null productions or productions clearly inferior to those cultivated in a suitable manner . Moreover, it has been observed that numerous fruit-bearing bodies form in a truffle-ground, but only a small percentage of them reach maturation: identifying the cultivation techniques, which could allow a greater percentage of truffles to grow and ripen, would mean hugely increasing the production of a truffle-ground .

Many experimental trials are under way in our Department (Baciarelli Falini *et al.*, 2000; Baciarelli Falini and Bencivenga, 2002) which, due to various hitches such as wild animals taking the truffles, have for the time being provided only incomplete and therefore statistically invalid data . Their interpretation, though, does allow for the possibility of giving indications, which we find interesting, regarding the cultivation of the truffle-grounds .

The following trials were carried out:

Irrigation: it has proved to be necessary in the year of planting to encourage the plants to take root (Fig.3) . During the productive stage, periodic irrigations beginning from mid-June until October depending on the weather conditions, have allowed abundant pro-

ductions of *Tuber melanosporum* to be obtained even in the dry years . The abundant irrigations have determined the substitution of the production of *T. melanosporum* with that of *Tuber brumale* in the soils which are low in calcium carbonate .

Hoeing: interventions were carried out at a depth of about ten centimeters on the vegetative renewal of the plants in April in the case of *T. melanosporum*, and in autumn in the case of *T. aestivum* . These interventions proved to be propitious for creating the ideal conditions for the growth of the fruiting body . The hoeing proved to be ineffective in very soft soil .

Soil covering: this practice turned out to be positive, but it still requires further testing above all in the choice of the material used to cover the soil (Fig.4) . Covering the “ pianelli ” (areas without herbaceous vegetation where black truffles grow) with a layer of soil, which is particularly suitable for the 8 - 10 cm thick black truffle, allowed excellent productions to be obtained even in the dry and hot years .

Pruning: pruning interventions in winter, but also in summer, do not discourage the production of the *Tuber melanosporum* truffle-grounds (Fig.5) . This fact is important because it permits a denser planting when compared to the past, and it also allows for a balanced shading of the truffle-ground to be maintained . The residue from the summer pruning can be used as a soil-covering material .

Sporal inoculation: the distribution of spores (mature truffle in the region of two grams per plant) around the root ball of the young mycorrhized plants at the time of transplanting encouraged the formation of “ pianelli ” in

a higher percentage of plants than in the control . Ten grams of inoculation distributed in the not very productive “ pianelli ” permitted an increase in production .

Weeding: Used only for containing the growth of the shrubs . In the truffle-grounds which tend to be infested by various shrubs, localized weeding is not harmful to the truffle-ground .

Soil correction: an intervention considered necessary in the cases of an incorrect evaluation of the suitability of the planting ground: when the pH of the soil is at the lower limit (7.5 - 7.6), the addition of 5 - 10 kg mq of calcium carbonate allowed some *Tuber melanosporum* and *T. aestivum* truffle-grounds to be made partially productive .

Soil conditioning: When the soil tends to become compact, the use of soil conditioning can be effective . This intervention has not been studied very much .

Fertilizations: partial experimental trials with organic or mineral fertilizers were conducted . We believe that it is important to do tests on the fertilizations as they could resolve the problem of the premature productive depletions observed in some *Tuber melanosporum* truffle-grounds . The fertilizations, moreover, could encourage the growth and the ripening of a greater percentage of the truffles which form in a truffle-ground .

The current situation of Italian truffle-growing

It is estimated that every year in Italy about 120 000 mycorrhized plants are bedded out in about 300 hectares of land . The species which are cultivated are above all *T. melanosporum* (80%) and *Tuber aestivum* (15%) . Very few plantations are created which



Fig . 3 Irrigation



Fig . 4 Surface covering



Fig . 5 Strong pruning in winter and in summer

have other species of *T. magnatum*, *T. brumale*, *T. borchii* truffle (5%). The average productions which are obtained in the cultivated truffle-grounds with reference to the various species of truffle are:

Tuber melanosporum The majority of the truffle-grounds set up in the last fifteen years (about 95%) are yielding variable productions with regard to the environment and the cultivating techniques adopted . Production ranges from a few kilograms per hectare to more than 100 kg hectare (Bencivenga e Di Massimo, 2000) .

Tuber magnatum Cultivation is difficult because it is difficult to recreate suitable environmental conditions for the fruit-bearing of the *Tuber magnatum* . The plantations set up in suitable environments began to produce limited quantities (2 - 4 kg hectare) of truffles after 15 - 20 years of the mycorrhized plants being bedded out (Fig.6) . The beginning of the productions occurred with the creation of environmental conditions suitable for the truffle to be able to bear fruit (total shading of the ground worked by the symbiont plants, enriching of the top layers of the soil with organic material originating from the leaves of the symbiont plants and the herbaceous vegetation, good porosity

and softness caused by the activity of the microfauna and the microflora) .



Fig . 6 Productive truffle bed of *Tuber magnatum* pico

Tuber aestivum The plantations created in Italy with the summer truffle are recent and therefore there is little productive data . The known productions often surpass 100 kg hectare .

T. borchii Pine-woods aimed at the production of the white truffle have been created in the coastal areas on extremely sandy ground, even if it has a neutral

or sub-acid pH .

The results are good or excellent . Negative results were obtained in very compact soils which are rich in clay .

T. brumale The production of *T. brumale* occurred in some *Tuber melanosporum* truffle-grounds created on soils which tend to be humid and compact and which are lacking in carbonates . Some plantations were recently created in soils with these characteristics using *Corylus avellana* and *Quercus pubescens* mycorrhized by *T. brumale* . The plantations are recent and still unproductive .

Current problems WTBZA first problem to occur in Italy was the production of truffles of a different species than the one with which the symbiont plants had been mycorrhized . In this case it may be a question of:

- a) Use of plants mycorrhized with other truffles;
- b) Setting up the truffle-ground in an environment which is unsuitable for the truffle that one wishes to cultivate .

A second problem is represented by the premature productive depletion of some plantations: the production begins, it is often abundant, but after 5 - 10 years it dries up . This problem has not been solved .

Other problems derive from the lack of experience in the cultivation of symbiont plants, as we are dealing with forest species which have never been cultivated in a field: often the truffle-farmer does not know how to fight against some parasitical adversities . or he does not know how symbiont plants react towards some agricultural interventions (for example, pruning, removal of shoots, etc .) .

Conclusions

Italy, because of its geological and orographic variability, is rich in environments where various species of truffle can be successfully cultivated . In fact, the most valuable species are present in all of the Italian Regions in the natural state: *Tuber magnatum* is gathered in the whole of the Peninsula (Fig.7); *T. melanosporum* in the whole of central-northern Italy and also in cultivation in the south; *T. aestivum* and *T. borchii* can be found in the whole of the Peninsula and on the Islands . Truffle-growing, therefore, has great possibilities for growth and it could constitute an activity capable of improving the socioeconomic condi-

tions of many populations living in the inner areas, and of resolving the ecological problems deriving from the desertion of the land . This kind of agriculture, in fact, has improved noticeably in the last year because the following factors have improved:

- a) The possibilities for evaluating the suitability of the environments for the cultivation of truffles;
- b) Plants which are definitely well mycorrhized and which have a mycorrhization certificate are bedded out;
- c) The knowledge of cultural techniques to be used in the truffle-grounds has improved .



Fig . 7 Italy

It is therefore necessary to widen the applied research in order to make truffle-growing more secure and productive: the research must be broadened to identify with greater precision the suitability of a soil for truffles (very little is known about the role of soil microflora and microfauna) and further testing must be done on the techniques of cultivating the plants in the field . In particular, the problems which bother the truffle-growers faced with a premature depletion of the productive activity in their truffle-ground must be resolved . In 1988, during the Second International Congress on the Truffle (1990), Ceruti, referring to the future targets of the research, declared: " the target will be to maintain the specific mycorrhization in the field and to promote the conditions for the formation of the *Astrocarya* " . The target is extremely current also due to the fact that in the last 20 years progress in this field has been somewhat limited . Finally we hope that the applied re-

search in the truffle and truffle-growing sector are motivated, coordinated and widened in order to improve this agricultural activity which is particularly important in Italy, a nation which has few plains and a lot of hills

and mountains, and where the difficulties faced in traditional agriculture have brought about a progressive depopulation and the abandonment of the ex-arable ground subject to ecological degradation.



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